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Bolt, Beranek and Newman, Inc.

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DATA BASE FOR PREDICTING NOISE FROM CIVIL AIRCRAFT:

FLIGHT PROFILE PREDICTION

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GLOSSARY OF SYMBOLS

a	=	distance in feet travelled during level flight acceleration.
b	=	horizontal distance travelled during constant speed section of accelerating climb (see figure 2b).
C_{11}	=	constant defined in equation (1) and derived from manufacturers' data.
C_{21}	=	constant defined in equation (5)
C_{31}	=	empirical constant defined in equation (8) for the i-th flap setting.
C_D/C_L	=	ratio of aircraft drag to lift coefficient for a specified flap setting and airspeed.
D	=	aircraft drag, lb.
EPR	=	engine pressure ratio
F_o	=	flat rated thrust for all engines, in thousands of pounds.
F_n	=	net thrust for all engines, in thousands of pounds.
F'	=	thrust available from all engines at ambient sea level temperature, in thousands of pounds.
FF	=	fuel flow, lb./hr.
g	=	acceleration due to gravity, ft./sec.^{2}
Δh	=	change in height during accelerating climb, ft.
L	=	aircraft lift, lb.
MSL	=	mean sea level
$\%N_1$	=	rotational fan speed expressed as a percentage of the value at maximum continuous thrust.
s_o	=	distance from brake release to point where the straight line extrapolation of the climb-out flight path intercepts the runway.

V, V_T = true airspeed, knots.

V_a = true airspeed after acceleration, knots.

V_b = true airspeed before acceleration, knots.

V_s = stall speed, knots.

V_w = wind component in the direction of flight (nosewind positive)

V_2 = takeoff safety speed; the lowest speed at which the aircraft complies with those handling criteria associated with the climb after takeoff following an engine failure, in knots.

W = takeoff gross weight, in thousands of pounds.

δ = ratio of ambient air pressure to U.S. Standard Atmosphere, Sea Level pressure.

σ = ratio of ambient air density to U.S. Standard Atmosphere, Sea Level density.

γ = angle between local flight path and horizontal, degrees.

γ' = flight path angle modified by wind component.

DATA BASE FOR PREDICTING NOISE FROM CIVIL AIRCRAFT: FLIGHT PROFILE PREDICTION

1. INTRODUCTION

Prediction of the noise produced on the ground by an aircraft in flight requires knowledge of two primary sets of information:

1) the trajectories of aircraft in the vicinity of the airport;

2) noise levels produce by aircraft under different operating conditions.

Regardless of the model used to compute noise levels from aircraft operations, information on flight trajectories, or more colloquially, "flight paths," is common to all. Flight paths at any particular airport are a function of many factors such as type of aircraft, aircraft weight, piloting procedure, traffic patterns, weather variables, field elevation. One of the basic requirements in any airport noise study is to define the flight paths in detail.

Definition of aircraft flight paths for noise analysis purposes can be decomposed into two parts. The first information the analyst generates is a description of the flight tracks (the projection of the flight path on the ground) for various aircraft types and operations. Most often this is accomplished by drawing lines on maps to indicate the flight tracks, although the USAF/EPA/NEF

program will generate such tracks from aircraft performance data and flight procedure descriptions if desired. Usually information on flight tracks is the only part of the flight path description that an analyst can obtain from field data at an airport.

In order to complete the description of the flight path, a means to obtain aircraft height, or profile, along the flight path is necessary. While flight tracks are governed primarily by local conditions, flight profiles are governed primarily by aircraft performance. The flight profile for any operating condition can thus be generated from a knowledge of the basic performance parameters for the aircraft, coupled with information on aircraft weight, piloting procedure, and atmospheric conditions.

This report describes a method for calculating flight profiles for any conventional fixed wing aircraft operating condition likely to occur in the vicinity of an airport, and provides performance parameters for aircraft currently operating in the U.S. civil fleet. The method uses certain simplifying assumptions for ease of computation, but provides adequate accuracy for prediction of the noise exposure produced by a complex set of operations around an airport.

In the following sections and appendices of the report we describe the methodology for generating flight profiles, the technique used to derive performance parameters, and a computer program for generating flight profiles from the data presented. It should be noted that all data derived in this report for turbine-powered aircraft are based on manufacturers' data as contained in certified operating

manuals for all-engine performance. Data for small aircraft are class averages derived from manufacturers specifications.

II. METHOD FOR DESCRIBING AIRCRAFT PROFILES

Precise estimation of the height of an aircraft under any operating condition on takeoff from or approach to an airport would require detailed information on engine performance, aircraft drag polars, runway surface conditions, weather and piloting procedure. For the purposes of generating aircraft height profiles to the accuracy required for noise prediction purposes, we can make a number of simplifying assumptions.* These assumptions will be discussed as each is introduced. In order to simplify the discussion, we will treat four separate operations:

1) takeoff distance
2) climb performance
3) acceleration in flight
4) approach

The discussion of each of these operations starts from an assumption that the airport involved is at sea level, ICAO standard day temperature and pressure, zero wind, zero runway gradient, dry runway. Corrections for nonstandard conditions will then be introduced as required.

A. Takeoff Roll

A precise description of the takeoff roll, gear retraction, and establishment at initial climb segment can be simplified for our purposes. It is assumed that the transition from liftoff, gear retraction, and establishment of the initial

*For most aircraft noise signatures a 10% error in aircraft height will result in an error of less than 1 decibel in noise level. The method developed here will usually provide height errors of the order of 1% or 0.1 decibel.

constant airspeed climb can be replaced by the "equivalent" ground roll distance established by projecting the initial climb gradient to intercept the runway as depicted in Figure 1.

For a given takeoff flap setting the distance, s_o, from brake release to the intercept point is quite accurately given by:

$$s_o = C_{1i} W^2 \qquad (1)$$

where C_{1i} is a constant derived from manufacturers' data for the i-th flap setting, and W is takeoff gross weight in thousands of pounds.

Corrections for non-standard temperatures can be approximated by dividing the standard takeoff distance by the ratio of air density of interest to standard air density, σ, as long as the engines are operated in their flat-rated temperature regime. For field elevations above sea level the takeoff distance must be increased further by dividing the standard day distance by the ratio of station pressure to standard pressure, δ. Finally, if the temperature is high enough to go beyond the flat-rated regime of the engine, the distance must be multiplied by the ratio of the flat-rated thrust, F_o, to the thrust available at the temperature of interest, F'. The general case of takeoff distance is then approximated by:

$$s_o = \frac{C_{1i} W^2 F_o}{\sigma \delta F'} \qquad (2)$$

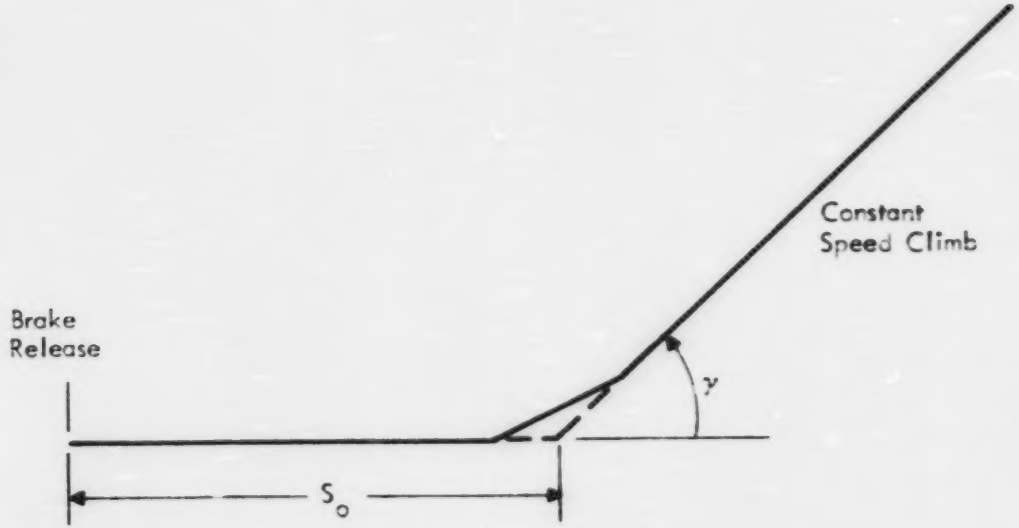


FIGURE 1. PROFILE GEOMETRY

B. Climb Performance

Climb performance of an aircraft is given by the general equation:

$$\frac{F_n}{W} - \frac{1.69}{g}\frac{dV}{dt} = \frac{D}{L}\cos\gamma + \sin\gamma \qquad (3)$$

where:

F_n = net thrust - thousands of lb.
W = aircraft weight - thousands of lb.
g = acceleration due to gravity - ft sec^{-2}
V = aircraft speed - knots
D = aircraft drag - lbs
L = aircraft lift - lbs
γ = climb angle - degrees

For our purposes we will assume the aircraft climbs at a constant airspeed, usually V_2 + 10 knots, except when accelerating to a new constant climb speed required for a reduced flap setting, that climb angles are sufficiently small that $\cos\gamma \approx 1$, and that D/L is given by the ratio of drag to lift coefficients, $\frac{C_D}{C_L}$, for a specified flap setting and airspeed. With these simplifications, the climb angle is given by:

$$\frac{F_n}{W} - \frac{C_D}{C_L} = \sin\gamma \qquad (4)$$

For a given flap setting we can approximate the climb airspeed by the expression:

$$V = C_{21}\, W^{\frac{1}{2}}\, \sigma^{-\frac{1}{2}} \qquad (5)$$

where V is true airspeed in knots, W is weight in thousands of pounds, C_{2_i} is an empirical constant for the i-th flap setting, and σ is air density ratio.

We are generally concerned with calculating profiles at altitudes of less than 10,000 feet and airspeeds at less than 250 knots. Under these conditions the thrust available can usually be approximated satisfactorily by multiplying the net thrust available at 750 feet at an airspeed of V_2 + 10 on a standard day by the ratio of altitude pressure to standard day pressure, δ. This approximation is not satisfactory for excessively hot days or for combinations of high by-pass ratios and high airspeeds that will disproportionately increase engine ram drag. Under these conditions, however, the aircraft subject to these conditions are not generally the major contributors to the airport's noise exposure and the resultant error is not significant.

Finally, aircraft climb angle will be affected by significant head or tailwind components. These factors may be considered by modifying the climb angle, γ, computed from equation (4) as follows:

$$\gamma' = \gamma\left(1 + \frac{V_W}{V_T - V_W}\right) \qquad (6)$$

where γ' is the new climb angle, V_W is the wind component (in knots), in the direction of flight (head wind positive), and V_T is the true airspeed of the aircraft in knots.

C. Acceleration

Once the initial climb airspeed is established, acceleration in the vicinity of the airport is usually restricted to

increasing the airspeed sufficient to retract flaps to the next lower flap setting of interest. While the true trajectory is accomplished by a combination of flap retraction, acceleration while climbing, and establishment of a new climb angle and airspeed, we can use one of two approximation procedures for noise prediction purposes.

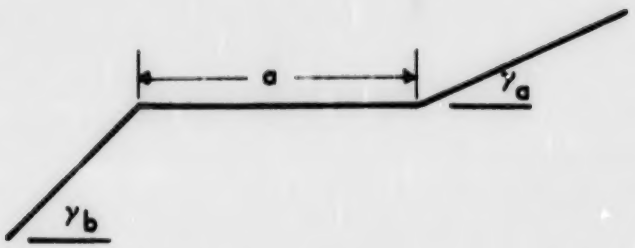
In the first procedure we assume the aircraft levels off, accelerates to the new climb airspeed while retracting flaps, then resumes climbing at the new airspeed. The second approximation applies when a specified altitude change takes place during the transition. These two procedures are indicated on Figure 2.

The distance in feet traveled during level flight acceleration, a, is given approximately by:

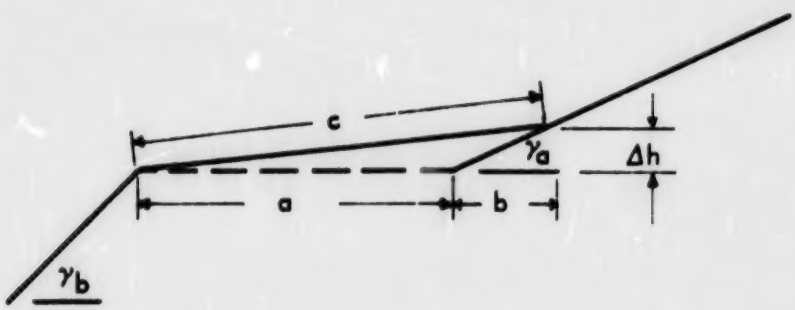
$$a = \frac{0.044\left(V_a^2 - V_b^2\right)}{\frac{F_n}{W} - \left(\frac{C_D}{C_L}\right)_a} \qquad (7)$$

where V_b and V_a are the true airspeeds in knots before and after acceleration, F_n is net thrust in thousands of pounds, W is weight in thousands of pounds, and $\left(\frac{C_D}{C_L}\right)_a$ is the ratio of drag to lift coefficients after the flap retraction.

The trajectory for acceleration while climbing can be approximated by calculating the distance b from the new climb angle and change in height, Δh. The profile is then the line C. The distance a is of course the same as given above by equation (7). A modified version of the program has been developed that limits the rate of climb to 500 feet per minute during the transition.



(a) LEVEL FLIGHT ACCELERATION



(b) ACCELERATION DURING CLIMB

FIGURE 2. SCHEMATIC OF ACCELERATION DURING CLIMB

D. Approach

Approach profiles are computed directly from equation (4), using the appropriate values of C_D/C_L for the flap settings used during approach conditions. Those given in this report are for gear down, at an approach speed of 1.3 V_s + 10 knots. Note that γ is a negative number during descent.

Allowance for wind conditions can be made in a manner similar to the takeoff correction in equation (6).

The airspeed in knots during approach is given in a similar expression to that for climb speed:

$$V_A = C_{3i} W^{\frac{1}{2}} \sigma^{-\frac{1}{2}} \qquad (8)$$

where C_{3i} is a constant for an aircraft at the i-th flap setting, W is weight in thousands of pounds, and σ is density ratio.

III CALCULATION OF PERFORMANCE PARAMETERS

A complete set of the performance constants described in the previous section of this report is provided in Appendix A. The methods for calculating these data are described here.

A. Takeoff Parameters

The sources of performance information used in this analysis were provided in most cases by the airframe manufacturers. A list of these documents is provided under "References."

The value of C_1, used to calculate s_o, was determined by projecting the climb gradient back to runway elevation for several gross weights and measuring the distance from the intercept to the start of takeoff roll. An average value of C_1 was then obtained using the relationship

$$C_1 = \frac{s_o}{W^2}$$

In computing the various parameters for the climb-out phase, several techniques were used depending on the format of the information. In some cases neither the drag nor the thrust information were available. In these cases the gradients for a number of different gross weights were used to obtain simultaneous equations. The values of drag and thrust data obtained in this way are not necessarily exactly equal to those used by the manufacturer to compute the performance; however, the resulting altitude profiles correspond very accurately to those presented in the operating manual. An example of the results of this technique is shown in Figure 3, which compares operating manual data and computed data for the Boeing 737 at 15° flap angle.

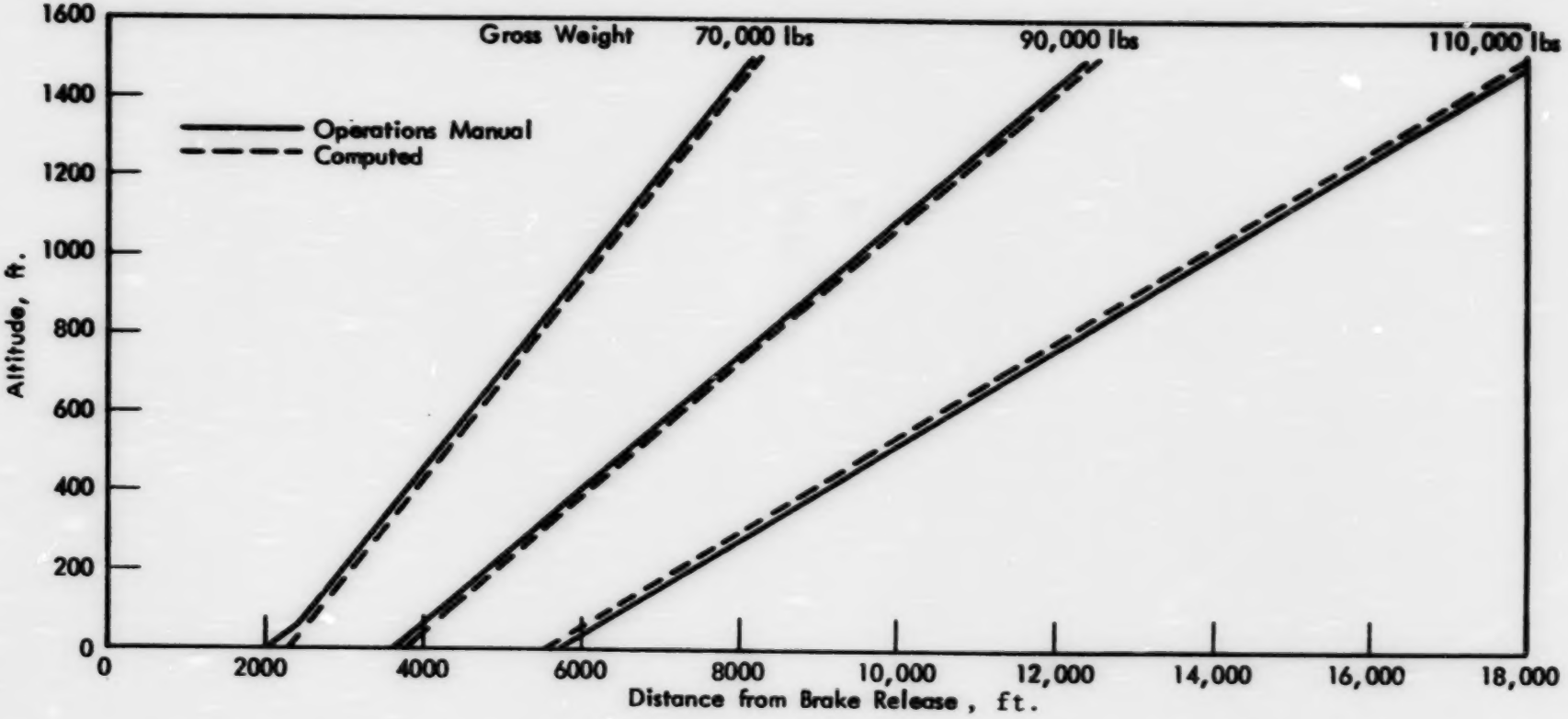


FIGURE 3. COMPARISON OF MANUFACTURER'S PROFILES WITH COMPUTED PROFILES

The primary cause for differences between operating manual profiles and those computed by the methods of this report are due to the simplifications used in stating single values for net thrust and C_D/C_L in the initial part of the climb. In the actual case net thrust will vary with operating weight due to the effect of different airspeeds on ram drag, and small differences in C_D/C_L will occur at different airspeeds. We have taken average values of net thrust and C_D/C_L over the normal range of operating weights and flap settings as the single values to use here, since a satisfactory approximation is obtained for community noise prediction purposes. Note also that the reference net thrust used here is the average thrust between sea level and an altitude of 1500 feet.

Data for the business jet aircraft were derived largely from information obtained during FAR Part 36 noise certification programs.

The performance parameters for the propeller aircraft (including gross weights) were chosen to generate the same altitude profiles as have been previously used in NEF computations (see Reference 7).

The reference airspeeds were available only for Boeing and business jet aircraft. Data for Douglas aircraft were estimated using the reference airspeed used in the noise data presented in the references.

Airspeeds for the propeller aircraft were not generally available. For the heavy (>12500 lb) aircraft, the speed was assumed to be 150 knots. A typical climb speed of 110

knots was assumed for general aviation light twin-engine and larger single-engine aircraft. The speed for single-engine aircraft less than 180 H.P. was assumed to be 90 knots. These figures are based on data in owner's manuals for these aircraft.

B. Calculation of Approach Parameters

For the jet aircraft the net thrust as a function of glide slope was available as part of the referenced information. This permitted calculation of the drag data using the above expression. Similarly, values of 1.3 V_s + 10 were provided, thus permitting computation of C_3.

For propeller aircraft the variation of approach power required at various heights, flap settings and approach angles has a minor effect on noise levels. The value of C_D/C_L of .15 is included for completeness, and is not necessarily the correct value. Values of C_3 are computed from estimated airspeeds. A typical airspeed of 130 knots was assumed for the heavy aircraft, 90 knots for light twin-engine aircraft, 80 knots for the larger (>180 H.P.) single-engine aircraft and 70 knots for the smaller aircraft.

C. Sample Calculation of Takeoff Parameters

Boeing 737 with JT8D-9 engines at takeoff thrust, 15° flap.

Table I shows the sequence of calculating the various parameters. The procedure used is as follows:

1) From operating manual data determine the distance from brake release to 35 ft altitude. Column 2.

TABLE I

SAMPLE CALCULATION OF TAKEOFF PARAMETERS

① Takeoff Gross Weight 1000 lbs	② 35' Dist.	③ Height 2000' After Col. 2	④ Added Distance to 1500'	⑤ Total Distance to 1500'	⑥ Climb Gradient tan γ	⑦ S_o	⑧ Corrected S_o	⑨ Climb Gradient Sin γ	⑩ C_D/C_L	⑪ Computed Distance to 1500'
70	2250	520	5900	8150	.2513	2181	2258	.2437	.07817	8306
80	2950	430	7200	10150	.2058	2860	2949	.2015	.08009	10278
90	3800	370	8600	12400	.1712	3639	3732	.1688	.08159	12469
100	4750	310	10200	14900	.1451	4614	4608	.1436	.08169	14903
110	5850	260	12200	18050	.1216	5711	5575	.1207	.08415	17609

Mean = .081137

Step 10.

$$.2437 = \frac{F}{70} - \frac{C_D}{C_L} \quad \text{For 70,000 lbs}$$

$$.1207 = \frac{F}{110} - \frac{C_D}{C_L} \quad \text{For 110,000 lbs}$$

Subtract to obtain:

$$F = 23{,}682 \text{ lbs}$$

For 5° Flap, F = 21,712 lbs
For 25° Flap, F = 22,199 lbs
Average, F = 22,531 lbs

2) From operating manual data determine the altitude 2000 ft along the flight track from the point at which 35 ft altitude is reached. The aircraft has reached a steady climb speed at this point. Column 3.

3) From operating manual data determine the distance between 35 ft. altitude at 1500 ft altitude. Column 4.

4) Add columns 1 and 3 to obtain total distance to 1500 ft altitude. This will be used later as a check. Column 5.

5) Determine the climb gradient, tan γ. Column 6.

6) Determine s_o using the climb gradient and distance to 1500 ft. Column 7.

7) Determine C_1 using the relationship

$$C_1 = \frac{s_o}{W^2}$$

and obtain an average. Sample case gives $C_1 = .46078$.

8) Determine a "corrected" s_o using C_1. Column 8.

9) Calculate sin γ from column 6. Column 9.

10) Use the maximum and minimum weights to generate two simultaneous equations in F and C_D/C_L using the relationship

$$\sin \gamma = \left(\frac{F}{W} - \frac{C_D}{C_L}\right)$$

Calculate F. Sample case gives F = 23,682 lbs.

11) Obtain F for the same aircraft with other flap settings and average these values. Sample case gives F = 22,531 lbs.

12) For each weight calculate C_D/C_L using the relationship in step 10, and average these values. Sample case gives C_D/C_L = .081137. Column 10.

13) For each weight make a check calculation using the values of C_1, F and C_D/C_L. Column 11. Compare with Column 5.

14) List climb speed for each weight (in this case V_2 + 15). Obtain C_2 = 15.053 to approximate this relationship, where speed = $C_1 \sqrt{W}$.

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APPENDIX A

PERFORMANCE PARAMETERS

TABLE A-I

PERFORMANCE PARAMETERS FOR JET AIRCRAFT

			Takeoff						Approach			
Aircraft Type	Engine Type	Aircraft Designator Code	Max. T.O. Weight	Thrust	Takeoff Flap Setting	C_D/C_L	C_1	C_2	Max. Landing Weight	Approach Flap Setting	C_D/C_L	C_3
Boeing 707-120B	JT3D-3	801	258.0	57.080	30	.11028	.09984	10.530	190.0	30	.11121	11.027
										40	.12775	10.882
										50	.14995	10.810
Boeing 707-300B	JT3D-3B	803	333.6	58.691	14	.09686	.0728	9.996	247.0	25	.1080	9.708
										40	.13505	9.506
										50	.15503	9.371
Boeing 707-300B QN	JT3D-3B	802	333.6	58.691	14	.09686	.0728	9.996	247.0	25	.1080	9.708
										40	.13505	9.506
										50	.15503	9.371
Boeing 720B	JT3D-1	804	234.0	53.400	20	.09134	.11772	11.209	175.0	30	.10909	11.037
				53.400	30	.10274	.10854	10.550		50	.14909	10.659
Boeing 727	JT8D-7	811	172.0	34.878	5	.10086	.28277	13.209	150.0	30	.14241	11.700
				34.878	15	.10466	.25919	12.545	142.5	40	.18369	11.542
				34.878	25	.11883	.23189	11.797				
Boeing 727	JT8D-9	812	184.8	37.140	5	.10086	.27169	13.209	154.5	30	.14241	11.700
				37.140	15	.10466	.24904	12.545	142.5	40	.18369	11.542
				37.140	25	.11883	.22281	11.797				
Boeing 727	JT8D-15	813	207.5	40.200	5	.10086	.24533	13.209	160.0	30	.14241	11.700
				40.200	15	.10466	.22488	12.545	142.5	40	.18369	11.542
				40.200	25	.11883	.20119	11.797				

TABLE A1 (Continued)

Aircraft Type	Engine Type	Aircraft Designator Code	Takeoff						Approach			
			Max. T.O. Weight	Thrust	Takeoff Flap Setting	C_D/C_L	C_1	C_2	Max. Landing Weight	Approach Flap Setting	C_D/C_L	C_3
Boeing 727 QN	JT8D-7	814	172.0	34.878	5	.10086	.28177	13.209	150.0	30	.14241	11.700
				34.878	15	.10466	.25919	12.545	142.5	40	.18369	11.542
				34.878	25	.11883	.23189	11.797				
Boeing 737-200	JT8D-7	821	103.7	22.531	5	.07490	.50509	15.729	98.0	25	.11491	14.3
				22.531	15	.08114	.46078	15.053		30	.12694	14.1
				22.531	25	.08545	.44569	14.661		40	.15681	13.7
Boeing 737-200	JT8D-9	822	109.0	24.760	5	.07490	.48760	15.729	98.0	25	.11491	14.3
				24.760	15	.08114	.44793	15.053		30	.12694	14.1
				24.760	25	.08545	.43802	14.661		40	.15681	13.7
Boeing 737-200	JT8D-15	823	115.5	26.140	5	.07490	.45455	15.729	103.0	25	.11491	14.3
				26.140	15	.08114	.40165	15.053		30	.12694	14.1
				26.140	25	.08545	.40083	14.661		40	.15681	13.7
Boeing 737-200 QN	JT8D-7	824	103.7	22.531	5	.07490	.50509	15.729	98.0	25	.11491	14.3
				22.531	15	.08114	.46078	15.053		30	.12694	14.1
				22.531	25	.08545	.44569	14.661		40	.15681	13.7
Boeing 747-100	JT9D-3A	831	710.0	122.818	10	.088	.018992	6.7278	564.0	20	.10970	6.887
				122.818	20	.09245	.01779	6.463		25	.11666	6.663
										30	.14289	6.395
Boeing 747-100 IMP	JT9D-3A	832	733.0	122.818	10	.088	.018992	6.7278	See Note			
				122.818	20	.09245	.01779	6.463				

NOTE: Approach parameters are the same for all models.

TABLE A-I (Continued)

Aircraft Type	Engine Type	Aircraft Designator Code	Takeoff						Approach			
			Max. T.O. Weight	Thrust	Takeoff Flap Setting	C_D/C_L	C_1	C_2	Max. Landing Weight	Approach Flap Setting	C_D/C_L	C_3
Boeing 747-100	JT9D-3A	833	712.0	127.928 127.928	10 20	.088 .09245	.017929 .016485	6.7278 6.463		See Note		
Boeing 747-100 IMP	JT9D-3A	834	735.0	127.928 127.928	10 20	.088 .09245	.017929 .016485	6.7278 6.463		See Note		
Boeing 747-100	JT9D-7	835	710.0	127.928 127.928	10 20	.088 .09245	.017929 .016485	6.7278 6.463		See Note		
Boeing 747-100 IMP	JT9D-7	836	733.0	127.928 127.928	10 20	.088 .09245	.017929 .016485	6.7278 6.463		See Note		
Boeing 747-100	JT9D-7A	837	712.0	135.003 135.003	10 20	.088 .09245	.01711 .01574	6.7278 6.463		See Note		
Boeing 747-100 IMP	JT9D-7A	838	735.0	135.003 135.003	10 20	.088 .09245	.01711 .01574	6.7278 6.463		See Note		
Boeing 747-200	JT9D-3A	839	743.0	122.818 122.818	10 20	.088 .09245	.018992 .01779	6.7278 6.463		See Note		
Boeing 747-200	JT9D-3A	841	769.0	127.928 127.928	10 20	.088 .09245	.017929 .016485	6.7278 6.463		See Note		

NOTE: Approach parameters are the same for all models.

TABLE A-1 (Continued)

Aircraft Type	Engine Type	Aircraft Designator Code	Takeoff						Approach			
			Max. T.O. Weight	Thrust	Takeoff Flap Setting	C_D/C_L	C_1	C_2	Max. Landing Weight	Approach Flap Setting	C_D/C_L	C_3
Boeing 747-200	JT9D-7	842	770.0	127.928 127.928	10 20	.088 .09245	.017929 .016485	6.7278 6.464	See Note			
Boeing 747-200	JT9D-7W	843	775.0	135.003 135.003	10 20	.088 .09245	.01711 .01574	6.7278 6.463	See Note			
Douglas DC8-55/61	JT3D-3B	805	325.0	58.691	15	.09235	.09375	9.985*	240.0	50	.13913	9.876
Douglas DC8-63	JT3D-7	806	355.0	62.478	12	.08448	.08656	10.084*	258.0	50	.12763	9.55
Douglas DC9-30	JT8D-9	825	108.0	26.343 26.343	5 15	.09885 .10728	.53012 .4616	16.358* 16.358*	99.0	50	.16127	13.900
Douglas DC9-30	JT8D-1 -7	926	108.0	25.315 25.315	5 15	.09885 .10728	.55534 .52177	16.358* 16.358*	99.0	50	.16127	13.900
Douglas DC10-10	CF6-6D	851	440.0	91.500 91.500	10 25	.11179 .15589	.03965 .03965	8.581* 8.581*	363.5	35 50	.13897 .17078	7.853 7.642
Douglas DC10-40	JT9D-20	852	530.0	118.532 118.532	10 25	.11179 .15589	.03948 .03948	8.687* 8.687*	380.0	35 50	.1329 .1678	8.054 7.797
BAC 1-11 SRS 400	R.R.Spey 511-14	827	88.5	19.480	8	.0773	.85927	17.759	78.0	45	.1502	15.512

NOTE: Approach parameters are the same for all models.

*Climb speeds were not available in the documentation provided for Douglas aircraft. These values were estimated from noise data reference speeds and should be updated from the flight manuals or a similar reference.

TABLE A-I (Continued)

			Takeoff						Approach			
Aircraft Type	Engine Type	Aircraft Designator Code	Max. T.O. Weight	Thrust	Takeoff Flap Setting	C_D/C_L	C_1	C_2	Max. Landing Weight	Approach Flap Setting	C_D/C_L	C_3
Grumman Gulfstream II	R.R.Spey 511-8	885	62.5	18.800	20	.10224	1.0812	22.687	58.5	39	.16242	20.265
Lockheed JetStar I	PT12A-6A	886	40.5	11.240	20	.1183	2.560	24.190	30.0	50	.1934	25.500
Lockheed JetStar II	TFE731-3	889	43.75	11.240	20	.1183	2.560	24.190	36.0	50	.1934	25.500
North American Sabre 70	PT12A-8	887	21.0	5.620	0	.0893	9.986	32.078	18.5	25	.1216	31.852
North American Sabre 80	CJ700-2D-2	888	23.3	6.890	0-15	.10425	6.315	28.693	22.0	25	.131	30.275
Commodore Jet Commander 1121	CJ610-5	882	17.5	4.940	25	.1097	11.358	32.988	16.0	60	.18616	33.375
Gates Learjet 25	CJ610-6	884	15.0	5.323	20	.1266	20.444	40.279	13.3	40	.17872	40.856
Cessna Citation	JT15D-1	881	10.35	3.108	15	.1065	21.004	36.212	9.9	40	.15415	36.232
Gates Learjet 35/36	TFE731-2	890	17.0	5.400	8	.08341	18.166	40.746	14.3	40	.19178	39.666

TABLE A-II

PERFORMANCE PARAMETERS FOR PROPELLER AIRCRAFT

		Takeoff						Approach			
Classification	Aircraft Designator Code	Max. T.O. Weight	Thrust	Flap Setting	C_D/C_L	C_1	C_2	Max. Landing Weight	Flap Setting	C_D/C_L	C_3
Large 4-Engine Propeller	901, 902*	150	27.839	Takeoff	.11	.2222	12.247	150	Approach	.15	10.614
Large 2-Engine Propeller >12,500 lbs.	911	40	7.899	Takeoff	.11	1.664	23.717	40	Approach	.15	20.555
Small 2-Engine Turboprop <12,500 lbs.	912	10	2.238	Takeoff	.11	19.48	37.947	10	Approach	.15	31.623
Small 2-Engine Propeller <12,500 lbs.	942	4	0.895	Takeoff	.11	121.75	55.00	4	Approach	.15	45.00
Single Engine Propeller >180 H.P.	954	3	0.671	Takeoff	.11	216.44	63.51	3	Approach	.15	46.19
Single Engine Propeller <180 H.P.	952	2	0.409	Takeoff	.11	373.4	56.57	2	Approach	.15	49.50

*901 = Lockheed Electra, Lockheed Hercules C-130E, Lockheed 383B
902 = Lockheed Hercules C-130H, Lockheed 382E, 382G

TABLE A-III

Engine Type (Aircraft Type in which installed)	Applicable range of EPR	Thrust ∿ EPR Relationship (or Thrust ∿ $\%N_1$, or Thrust ∿ Fuel Flow)
PT12A-8 (Sabre 70)		Thrust = 5.62 (1+0.8007 (EPR-2.2))
PT12A-6A & TFE 731-3 (JetStar I & II)		Thrust = 11.24 (1+0.8007 (EPR-2.2))
JT15D-1 (Cessna Citation)		Thrust = 3.108 (1+0.02511 ($\%N_1$-94))
CJ610-5 (Jet Commander 1121)		Thrust = 4.94 (1+0.6749 (EPR-2.4))
CJ610-6 (Lear 24/25)		Thrust = 5.2 (1+0.6412 (EPR-2.4))
CF700 Series		Thrust = 6.89 (1+1.873 (EPR-1.54))
RR Spey 511		Thrust = 18.8 (1+0.00012869 (FF-7200))

TABLE A-III (Cont'd)

RELATIONSHIP BETWEEN THRUST AND EPR, $\%N_1$ OR FUEL FLOW

Engine Type (Aircraft Type in which installed)	Applicable range of EPR*	Thrust ∿ EPR Relationship (or Thrust ∿ $\%N_1$, or Thrust ∿ Fuel Flow)
JT3D	EPR < 1.45 1.45 ≤ EPR ≤ 1.7 1.7 < EPR ≤ 1.83	Thrust = 38 (1 + 1.077 (EPR - 1.45)) Thrust = 52 (1 + 1.077 (EPR - 1.7)) Thrust = 58.7 (1+0.877 (EPR-1.83))
JT8D (Boeing 727)	EPR < 1.6 1.6 ≤ EPR ≤ 2.11	Thrust = 24.3 (1+1.5586 (EPR-1.6)) Thrust = 34.979 (1+0.8824 (EPR-1.94))
JT8D (Boeing 737 and Douglas DC-9)		Thrust = 22.531 (1+0.8824 (EPR-1.95))
JT9D		Thrust = 135.003 (1+1.587 (EPR-1.43))
CF6		Thrust = 91.5 (1+0.02579 ($\%N_1$-100))

*EPR bounds are set by minimum thrust applicable to a given flight condition and maximum available thrust.

APPENDIX B

COMPUTER PROGRAM USER GUIDE

APPENDIX B

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APPENDIX B

COMPUTER PROGRAM USER GUIDE

I. INTRODUCTION

The computer program consists of a main program and 19 subroutines. It is written in the FORTRAN IV language as defined for the Control Data 6000-series high-speed digital computers. We will discuss input and output first and follow this with a brief summary of the function of each module.

II. INPUT

A. Input Format

Data input is on punched cards. The operation to be calculated may have several segments. The first card (type 1) is therefore different from the following (type 2 data card). The format of the type 1 card is the same for takeoffs and landings, but the type 2 card is different. Subsequent segments are punched on additional type 2 cards.

The program will continue to read cards until an end-of-record or end-of-file is encountered. Errors in the data input will result in a diagnostic message and termination of the run.

B. Data Card 1 Format

Columns	Data	FORTRAN Format
1-4	Operation = 0 Takeoff = 1 Landing	I4
5-8	Aircraft Designator (see list: Appendix A)	I4
9-12	Flap Setting (degrees)	I4
13-16	Weight Specification: 0 if in klbs. 1 if in % of max. gross	I4
17-24	Aircraft weight in klbs. or % of max. gross	F8.0
25-32	Field altitude (ft.)	F8.0
33-40	Altitude to be climbed to on this segment (takeoff) or altitude from which descent starts on this segment (landing) (ft.)	F8.0
41-48	Glide slope (for landings) (degrees)	F8.0
49.52	Flight number	I4

Note: A description of these parameters appears in Section IIC.

Data Card 2 Format (Takeoffs)

Columns	Data	FORTRAN Format
1-4	Mode Parameter: = 1 Change Power Setting Only = 2 Change Flaps and Speed = 3 Change Speed Only = 4 Change Power and Speed = 5 Change Power, Speed and Flaps	I4
5-8	Flap Setting (degrees)	I4
9-12	Power Parameter: = -1 Power in terms of rate of climb = 0 Power in terms of EPR, $\%N_1$, or fuel flow = +1 Power in terms of thrust	I4
13-20	Power specification in rate of climb, EPR, or thrust as specified by parameter in col. 9-12	F8.0
21-28	Highest altitude of this segment (ft.)	F8.0
29-36	Speed (see text) (knots)	F8.0
37-40	Continuation = 0 Last segment = 1 Another segment follows	I4

Note: Even though the required operation may involve only one segment, at least two cards must be submitted for each operation.

Data Card 2 Format (Landings)

Columns	Data	FORTRAN Format
1-4	Change Parameters: = 1 Change glide path only = 2 Change flap setting only = 3 Change glide path angle and flap setting	I4
5-8	Flap setting for this segment (degrees)	I4
9-16	Highest altitude of this segment (ft.)	F8.0
17-24	Glide slope angle (degrees)	F8.0
25-28	Continuation = 0 last segment (furthest out) = 1 another segment follows	I4

Note: Even though the required operation may involve only one segment, at least two cards must be submitted for each operation.

C. Comments on Input Parameters

User Input - First Input Card

The user provides input on cards in the format as specified here. The first card specified:

1) Type of operation (takeoff or landing)
2) Aircraft designator code
3) Takeoff flap setting
4) The manner in which the weight is specified (klbs or % of maximum weight)
5) Aircraft weight
6) Field altitude (MSL)
7) Altitude (MSL) at which aircraft makes first configuration change
8) Approach angle
9) Flight number

Note that the first four input parameters and the last (#9) must be integers (no decimal points) and each must appear in the rightmost position in the 4-digit field. The next four are floating point numbers and each occupies an 8-digit field (including decimal point). The system will assume a decimal after the last digit unless a decimal point is supplied.

Considering each of the input parameters separately:

1) Type of operation
This parameter is set equal to 0 for a takeoff, 1 for a landing; no other values are permitted.

2) Aircraft designator code
There are 47 types of aircraft, each one a separate type or a member of a group with a unique model engine; see Appendix A for details.

3) Flap setting
Each aircraft has permissible takeoff and landing flap settings; consult Appendix A for permissible settings. Illegal settings will cause an abort. Zero degrees is permissible for takeoff only for aircraft types 887 and 891 and in no case for landings.

4) Weight specification mode
Set this parameter for 0 if you wish to specify weights in klbs. Set it to 1 to specify weight in percent of maximum weight.

5) Weight
Specify weight in form indicated in the above paragraph. Note that takeoff and landing maximum weights are often different.

6) Field altitude
Specify field altitude in feet above sea level. This is used to set engine power correctly on takeoff, and set height correctly on landing.

7) Configuration change altitude
Specify the altitude where the first configuration change takes place (on takeoff) or the last change (on approach). Altitude in feet above sea level.

8) Angle of approach
Specify angle, in degrees with the horizontal, of the final approach. This parameter has no effect on takeoffs.

9) Flight number
This is a reference number which is simply passed through to the output for use by the NEFUSAF program.

The program will use the information on the first card to construct the flight segment from the runway (start of takeoff roll, or 50 ft. above landing threshold) up to the altitude specified in item #7 on the first card (called ALT1). It will do this using the specified flap setting (FLAP) and weight (WT). For takeoffs, maximum thrust will automatically be chosen. Landings use the approach angle specified (ANGLE) and derive the required thrust.

The system checks all input parameters that it reasonably can. It is suggested that the user intentionally violate some of the restrictions (wrong type number, wrong flap setting, overwieght, etc.) to become familiar with the error modes of the system.

User Input - Second Input Card - Takeoffs

The second (and additional) input cards have different parameters for takeoff and landing. This section describes the cards used in the takeoff routine. The parameters specified on the second card are:

1) Type of maneuver to be performed
2) Flap setting
3) The manner in which power is specified (thrust, EPR, $\%N_1$ or fuel flow or rate of climb)
4) Power
5) Altitude of next change
6) Speed at end of maneuver
7) Whether this is the last card or not

The first three items, and the last item, are integers, to be placed on the right side of a 4-digit field. Items (4), (5), and (6) are floating point numbers in an 8-digit field.

Considering these parameters separately:

1) MODE
   Five modes or maneuvers are possible:
   1) Change power setting only
   2) Change flap setting and speed
   3) Change speed only
   4) Change power and speed
   5) Change power, speed and flap setting

2) FLAP2
   Same as for first card, except that zero degrees is permissible.

3) PWRMOD
   -1 indicates "PWR" is in rate-of-climb units (feet per minute); 0 indicates PWR in EPR*, 1 indicates PWR in thrust (klbs.).

4) PWR
   Power in form indicated above. Value is checked for too high or too low.

5) ALT2
   Altitude (MSL), in feet, where this next segment ends.

6) SPD2
   Speed, in knots, at end of segment.

7) RPT
   If RPT = 0, this is the end of the climb for this flight.
   If RPT = 1, another card (identical in format to this one) is read.

---

*For CF-6 and JT-15D use $\%N_1$, and for R.R. Spey use fuel flow in lb/hr instead of EPR for PWRMOD = 0.

Note that all power changes are checked for compliance with FAR Part 36: minimum thrust is either (1) thrust to maintain level flight with one engine out, or (2) thrust to maintain 4% climb, all engines, whichever is greater. Note also that if the new flap setting is anything other than 0 degrees, the only allowable speed at the end is V_2 + 10 for that flap setting. If the new flap setting is 0 degrees, the speed must be equal to, or greater than, V_2 + 50, where V_2 is defined for the smallest (non-zero) takeoff flap setting for that aircraft. The first speed restriction (V_2 + 10 with flaps) means that modes 3 and 4 can only be used if the flaps start and stay at 0 degrees (meaning that modes 3 and 4 cannot be used until the third segment, except for aircraft Nos. 891 and 887. Any other value will cause an abort.

User Input - Second Card - Approaches

The parameters specified on the second approach card are:

1) Type of maneuver to be performed
2) Flap setting
3) Next altitude
4) Next glide path angle
5) Whether this is the last card

The first, second and fifth items on this card are integers, to be placed on the right side of a 4-digit field. The others are floating-point numbers in an 8-digit field.

Considering the items separately:

1) MODE

There are three possible maneuvers:

1) Change glide path angle
2) Change flap setting

3) Change both glide path angle and flap setting.
These three possibilities are selected by setting MODE equal to 1, 2 or 3, respectively.

2) FLAP2
This is the flap setting for this segment (if the flap setting is being changed). Note that 0 degrees is legal, but that the system checks for a situation requiring less than minimum thrust (minimum thrust is set equal to 5% of maximum thrust).

3) ALT2
This is the next altitude back (remember that we work backwards from the runway). This altitude can be the same as the previous one, but ANGL2 must then equal 0. Failure to make these agree will cause illogical results (there is no protection for this).

4) ANGL2
This is the glide path angle of this segment. Zero is permissible. Too steep an angle may cause an abort because of a requirement for too low a thrust setting (particularly with less than full flaps).

5) RPT
This operates in the same manner as the same variable in the takeoff section.

Note that in this section there is a major change in operating procedure compared to the rest of the program. No data is put out until the details of the next segment are determined. This is so because, to effect a smooth transition, the end of the previous segment is moved back 250 feet, and the start of the present segment moved forward 250 feet. The smoothing segment is set at an angle halfway between the angles of the two adjoining

segments (when the glide-path angle is being changed). When it is determined that the previous segment was the final segment, one additional point is put out, and the program ends operation.

III. INTERPRETATION OF DATA OUTPUT

A. Printed Data Output

(These descriptions apply to a two-segment takeoff or approach; other configurations will have a slightly different output.)

1. TAKEOFF

The program first outputs some of the input data applicable to the first climb segment. If the input gross weight is greater than the maximum allowable gross weight, the program prints out the corrected gross weight.

The takeoff profile is listed from brake release as follows:

Line 1: Profile data are listed at brake release.

Line 2: Data are listed at the intersection of the first segment climb profile and the runway. The referred and net thrusts are both given. The referred thrust is the thrust at sea level and will be greater than the thrust quoted in the tabulated performance parameters. This is because the tabulated thrust is equal to the thrust at 750 feet above sea level.

Next the initial climb speed (usually V_2 + 10) is printed.

Line 3: Profile data are listed at 2000 ft. intervals to the end of the first segment. If the first segment is less than 2000 ft. in altitude, the program lists the data at the end of the first segment.

The target speed is listed next, which is the minimum allowable speed (see Appendix B, Subroutine MINSPD), or a speed specified by the user, whichever is greater.

Line 4: The program allows 2000 ft. to complete the transition between segments. This line prints the profile data at the end of the transition maneuver.

Line 5, and subsequent lines: Profile data are printed at 2000 ft. altitude intervals to the end of the next segment.

If there are more than two segments, a new target speed may be set, and a new transition maneuver calculated.

2. LANDING

For both input and output, data are specified from the runway out, so that for landings data are printed for a sequence going backwards in time. The program first outputs some of the input parameters applicable to the approach segment closest to the runway.

The landing profile is then listed from the runway threshold outward:

Line 1: Profile parameters measured at the landing threshold; the aircraft is defined to be at an altitude of 50 ft. at this point.

Line 2: The program calculates the distance from the threshold to the end of this segment, with the height of the segment defined as an input parameter, but parameters at this point are not printed. In order to leave space for a

segment change transition maneuver the program backs up along the segment to a point 250 ft. downrange from the end of the segment, and outputs the profile parameters at that point.

Line 3: The program calculates the distance travelled and change of height in carrying out the transition maneuver. It then adds these figures to those listed on the previous line.

Line 4: If there are more than two segments to the landing profile, the program performs the same calculations for the end of the second segment out as it did for the first. If there are two segments, the program outputs the profile parameters at the outer end of the second segment, the height of which is specified by the user.

(Line 5:) If there are more than two segments, the program outputs profile parameters at the outer end of the transition between the second and third segments.

Line 5 and subsequent lines will only be printed if there are more than two segments, each pair of lines indicating the start and end of each segment, with a transition between each segment.

B. Punched Data Output

The format of the punched output depends on the number of data points generated for each output run, as follows:

1. Three or less data points

First card:

Card Column	Data	FORTRAN Format
1-6	ALTUDE	6H
7-8		2X
9-11	Aircraft descriptor Code	I3
12-14	Flight #	I3
15-22		8X
23-30	1st data point distance	F8.0
31-38	1st data point altitude	F8.0
39-46	2nd data point distance	F8.0
47-54	2nd data point altitude	F8.0
55-62	3rd data point distance	F8.0
63-70	3rd data point altitude	F8.0
71		1X
72-74	Aircraft descriptor Code	I3
75	Operation descriptor = L for landing for takeoff = T	
76-78	Aircraft gross weight (klbs.)	F3.0
79-80		2X

Second card (if more than seven data points):

Card Column	Data	FORTRAN Format
1-6		6X
7-14	4th data point distance	F8.0
15-22	4th data point altitude	F8.0
23-30	5th data point distance	F8.0
31-38	5th data point altitude	F8.0
39-46	6th data point distance	F8.0
47-54	6th data point altitude	F8.0
55-62	7th data point distance	F8.0
63-70	7th data point altitude	F8.0
71		1X
72-74	Aircraft descriptor code	I3
75		
76-78	Aircraft gross weight (klb.)	F3.0
79		1X
80	*	H1

Last Card

The last card has the same format as above except that the asterisk is omitted.

IV. DESCRIPTION OF ROUTINES

Main Program ACPERF

This program reads the cards and calls the pertinent subroutines to generate the profile. Checks are performed so that valid parameters are passed. All power changes are checked to see that they comply with FAR Part 36 certification standards: the greater of (a) thrust to maintain level flight with one engine out, or (b) thrust to maintain 4% climb on all engines.

If flap setting is anything other than 0 degrees, the only allowable speed is V_2 + 10 for that flap setting. If the new flap setting is 0 degrees, any speed above V_2 + 50 is allowed where V_2 is the V_2 for the smallest non-zero flap setting available for takeoff for the aircraft. This means that mode 3 and 4 can only be used if the flap setting starts and remains at 0 degrees.

Subroutine ACCLMB

This routine accelerates an aircraft while climbing. It does this by constructing the piecewise equivalent in energy. Thus, the distance required to accelerate the aircraft in level flight is added to the distance required to climb at constant speed to the desired altitude. The extreme end points of these are used to construct the equivalent straight line path. This path can extend, at most, 2000 ft. vertically. If the segment distance is longer, routine MKSEG is called to construct additional sections. A second version of the program exists that limits the rate of climb to 500 feet per minute during the transition.

Subroutine ACTYPE

This routine matches the aircraft type used flap settings and returns C_D/C_L, C_1 and C_2.

Subroutine APPSEG

This routine constructs an approach segment of constant angle and speed. Checks for thrust within range are also performed.

Subroutine APTYPE

This routine sets the approach parameters C_D/C_L, C_2, idle thrust and maximum landing weight.

Subprogram BLKDATA

The block data subprogram initializes the various tables of aircraft parameters.

Subroutine CHFLP2

This routine changes the speed of the aircraft on the approach in response to a change in flap setting; the aircraft continues on a constant angle glidepath throughout. The procedure used is as follows:

1) Maintain trust at the setting for the next segment out
2) Calculate additional drag due to the flap change
3) Calculate deceleration
4) Calculate speed for the next segment in
5) Calculate distance travelled

Subroutine CHGPWR

This routine changes power smoothly over a short horizontal distance. It does not change flap setting or speed. It is assumed that the uncorrected thrust values for starting and

stopping the routine, starting position, altitude, and speed of the aircraft are provided.

Subroutine CKDECH

This routine punches the data cards for the NEF program.

Function DELTA

This function performs a table look-up and interpolation to find the value of the relative pressure of the atmosphere. This value modifies the thrust of an aircraft engine according to altitude.

Subroutine MINSPD

This routine calculates a minimum speed based on the following considerations:

1) If flaps are not at zero degrees, the speed must be V_2 + 10 for this flap setting.

2) If flaps are at, or going to, 0 (full up), then the final speed is V_2 + 50 for the smallest non-zero flap setting, or the speed is that requested by the user, whichever is greater.

Subroutine MKSEG

This subroutine constructs climb segments during which no changes are made. Ending position is calculated from starting position, starting and ending altitudes, aircraft weight and C_D/C_L.

Subroutine PRINHD

This routine prints headings for data output.

Subroutine PARAFR

This routine prints input data.

Subroutine PUTOUT

This routine prints the output information.

Subroutine PWRTHR

This routine arrives at a thrust value from the aircraft type, aircraft weight and C_D/C_L. Each aircraft has a unique relationship, although sometimes the only difference is in the allowable limits. A power setting too high (e.g. EPR = 100) or negative will result in the program selecting maximum continuous thrust (93.3% maximum). This routine also sets power in accordance with FAR Part 36 as follows: (1) power must be such that level flight can be maintained with one engine out, or (2) such that at least a 4% climb is possible with all engines. Whichever requirement is greater controls the minimum power setting.

Function SIGMA

This function performs a table look-up and interpolation to find the relative density of the atmosphere. This value modifies the takeoff distance and speed of an aircraft according to altitude.

Subroutine TYPCOD

This subroutine converts the aircraft designator code on the first input card into a different code that is internally compatible with other subroutines in this program.

Subroutine TKFCLM

This subroutine takes the aircraft through takeoff and initial climb. If the initial climb extends over a greater altitude than 2000 ft., routine MKSEG is called to insert one or more sections until reaching the specified altitude. The input is: field altitude, aircraft weight, C_D/C_L, C_1, C_2, thrust, and altitude at which first configuration change is made.

Functions COSD and SIND

These functions return the cosine and sine of an argument in degrees. If such routines are available as the computer system's FORTRAN library, these routines should be removed.

V. EXAMPLES

The following examples of a takeoff and landing illustrate the input and output from this program. Figure B.1 shows a sample set of input data for a landing and takeoff. The first two cards are for a landing, with the following input parameters:

First Card (parameters pertaining to segment closest to runway)

Type of operation:	Landing
Aircraft type	Boeing 707-120B
Flap setting on final approach:	40°
Weight specification:	klb.
Aircraft weight:	190,000 lb.

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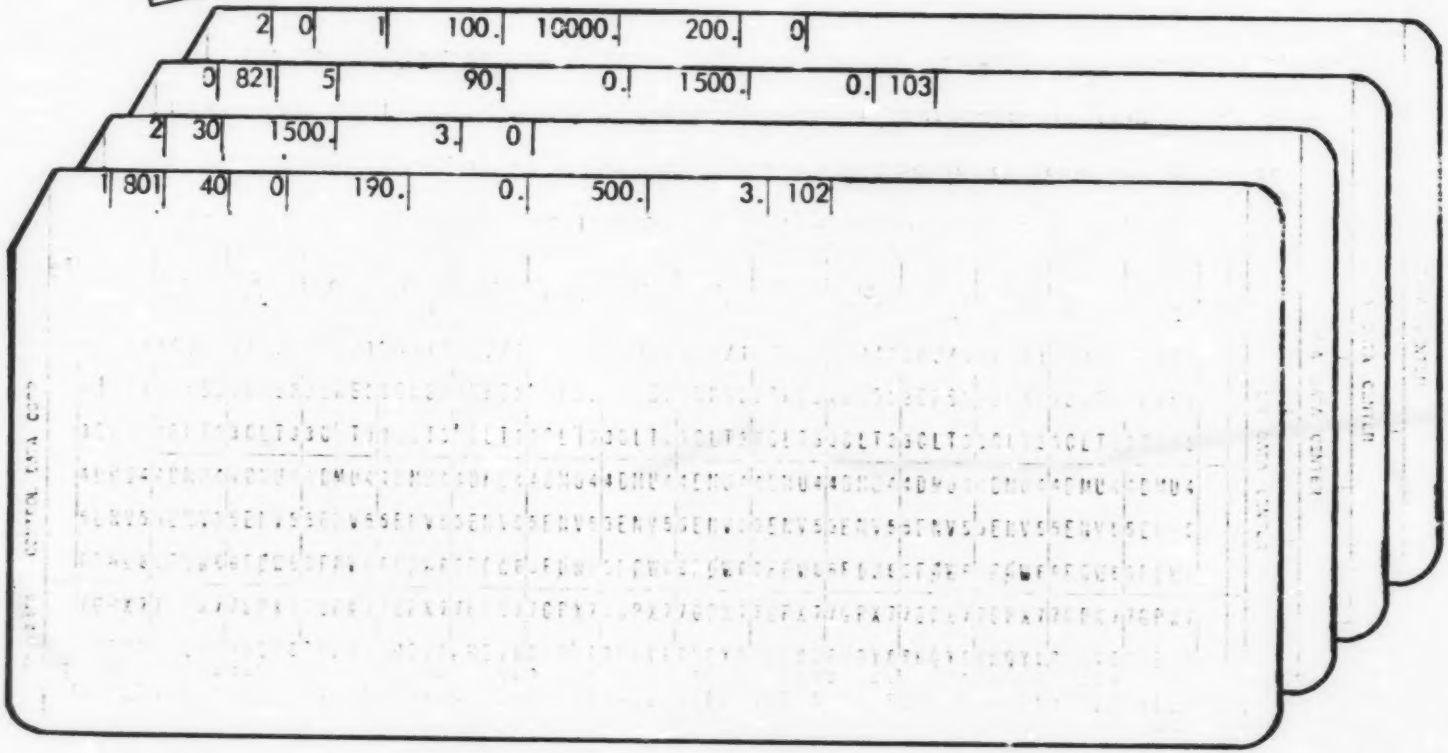

FIGURE B.1 DATA INPUT TO PROGRAM

Field Altitude:	0 ft.
Height of this segment:	500 ft.
Glideslope:	3°
Flight number:	102

Second Card (parameters pertaining to next segment out from runway)

Change parameters:	Change flap setting only
Flap setting on this segment:	30°
Highest altitude of this segment:	1500 ft.
Glide slope angle:	3°

Is this the last segment from the runway? Yes.

Figure B.2 shows the printed output corresponding to these input cards. As described in this appendix, Section III.A.2., parameters are not actually listed at the end of each segment, but at the beginning and end of each transition between segments. The transition maneuver is assumed to be about 500 ft. long, so one end of the transition (the end nearest the runway) is fixed at 250 ft. downrange from the end of the segment. In this particular example the transition distance was less than 250 ft., so that the flight profile parameters for the outer end of the transition maneuver actually occurred at a height less than the nominal height of the segment. If the transition distance were more than 250 ft., this would not occur.

Returning to the input data cards, the next pair of cards represent a takeoff with the following parameters:

First Card

Type of operation:	Takeoff
Aircraft type:	Boeing 737-200
Takeoff flap setting:	5°

TYPE OF OPERATION- LANDING FLIGHT NO. 102
AIRCRAFT TYPE NO. ON PERFORMANCE PARAMETER LIST 801
LANDING WEIGHT- 190.0 KLB. APPROACH FLAP SETTING- 40 DEGREES
FIELD ALTITUDE 0. FT. HEIGHT OF FIN. SEG.- 500. FT.
GLIDESLOPE 3. DEGREES

FLIGHT PATH PROFILE

DISTANCE FROM BRAKE RELEASE (FT.)	HEIGHT	NET THRUST (KLB.)	REFERRED THRUST (KLB.)	TRUE AIR SPEED (KNOTS)
0.	50.	14.32	14.34	150.
8337.	487.	14.32	14.57	150.
9946.	571.	11.17	11.41	152.
27668.	1500.	11.17	11.80	152.

END OF RUN

FIGURE B.2 PRINTED OUTPUT : LANDING

Weight specification:	klb.
Aircraft weight:	90,000 lb.
Field altitude:	0 ft.
Height of this segment:	
Glide slope:	Not relevant
Flight number:	103

Second Card (parameters pertaining to next segment out from runway)

Mode parameter:	Change flaps and speed
Flap setting:	0°
Power parameter:	Power in terms of thrust
Engine thrust:	Not used, since only flaps and speed are specified to be changed
Highest altitude of this segment:	10,000 ft.
Speed on this segment:	200 knots

Is this the last segment? Yes.

Printed output corresponding to the second pair of input cards is shown in Figure B.3; an interpretation of this output appears in Section III.A.1 of this appendix.

Punched data output for both landing and takeoff profiles is shown in Figure B.4. The format of these cards is such that they may be used directly in the USAF/EPA/NEF computer program (Ref. 1). An interpretation of punched output appears in Section III.B. of this appendix.

Ref. 1.

Reddingius, N. H., *"Community Noise Exposure Resulting from Aircraft Operations: Computer Program Operators' Manual,"* AMRL-TR-73-108, Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio (June 1974).

TYPE OF OPERATION - TAKEOFF FLIGHT NO. 103
AIRCRAFT TYPE NO. ON PERFORMANCE PARAMETER LIST 821
TAKEOFF WEIGHT- 90.0 KLB. T/O FLAP SETTING- 5 DEGREES
FIELD ALTITUDE- 0. FT. HEIGHT OF 1ST SEG- 1500. FT.

FLIGHT PATH PROFILE

DISTANCE FROM BRAKE RELEASE (FT.)	HEIGHT	NET THRUST (KLB.)	REFERRED THRUST (KLB.)	TRUE AIR SPEED (KNOTS)
0.	0.	23.14	23.14	0.
4091.	0.	23.14	23.14	149.

INITIAL CLIMB SPEED IS 149. KNOTS

12504.	1500.	21.92	23.15	149.

TARGET SPEED SET TO 200. KNOTS

18058.	1657.	21.80	23.15	200.
29924.	3657.	20.25	23.15	200.
43140.	5657.	18.81	23.18	200.
57943.	7657.	17.45	23.18	200.
74597.	9657.	16.17	23.19	200.
77669.	10000.	15.96	23.19	200.

END OF RUN

FIGURE B.3 PRINTED OUTPUT : TAKEOFF

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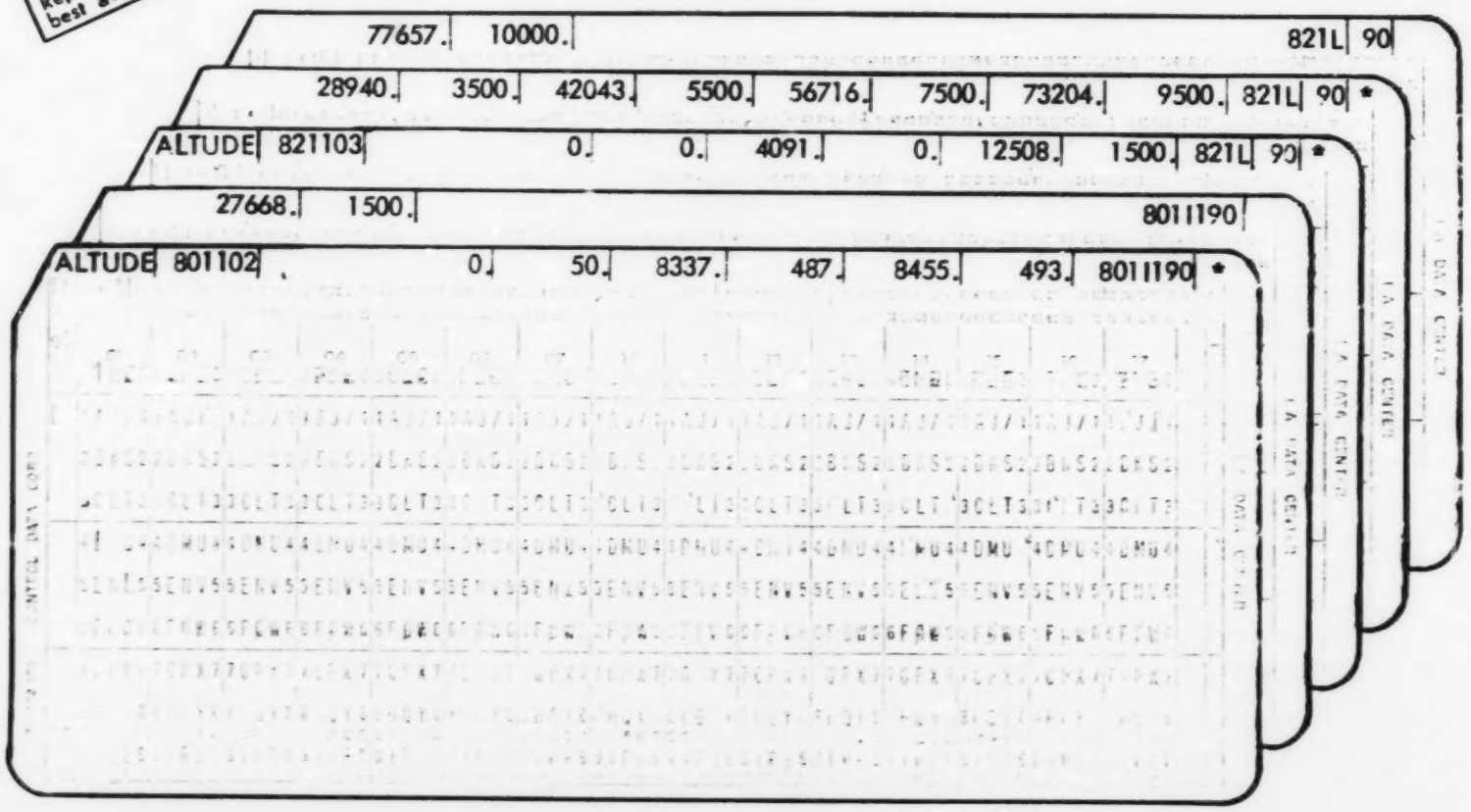

FIGURE B. 4 PUNCHED OUTPUT FROM PROGRAM